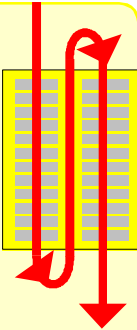



Instructions

Scrolling through a two-column document on-screen from the bottom of one column to the top of the next, and so on, can get very tedious. Fortunately, "column threading" is automatic with this software. Here are the basic tools and techniques that you need to know to efficiently navigate through the columns in this document ...



1. Click on the hand tool in the button bar. 

2. Whenever the hand cursor is positioned over a column, the cursor changes to the "read article cursor",  and "Read Article" appears in the status bar to indicate that this text is part of an "article". *An article is a collection of columns selected by the editor that comprise one subject, like one of the articles on the front page of a newspaper. Each first-level section (1.1, 1.2, 1.3...) of the NTIA Manual has been defined as a separate article.* Click any part of the article to start reading at that point, or control-click to start at the beginning of the article. The cursor now changes to the follow-article cursor, and "Follow Article" appears in the status bar.



3. To page down, simply click the mouse, or use the scrollbar, or press the PageDown key. *You can keep track of where you are on the page if you're using the thumbnails-and-page view. In this view a selection rectangle moves over a thumbnail of the page as you scroll through the columns in the page view window.*




4. You can continue to click until you reach the end of the article. At the end of the article, the cursor changes to the end-article cursor, and "End Article" appears in the status bar. Click again to return to the page view displayed before you started reading the article. Click the fit page button.


5. If you want to exit before the end of the article...

- select any navigation method (but not Enter or Return)
- Go to another article or page
- Hold down Shift + Ctrl and click.



6. You can also select which article (NTIA Manual Section) to view by choosing “Articles...” from the View menu, and then selecting the article you want from the dialog box that appears. *You can keep this dialog box displayed so you can go from one article to another better yet, use the bookmarks method described in #7 below.*

7. The **best way** to select which article (NTIA Manual Section) to view is to switch to the “Bookmarks-and-Page” view, click  on the section name bookmark, **click with the hand cursor on the page**, then navigate with the hand tool as described in #1-5 above. Links to all of the sections are provided — as well as links to tables, figures, endnotes, and even these instructions.

8. To select text within a column, click the text selection tool, hold down the Control key, and drag to select the text you want to copy. 

ANNEX B

Data and Procedures for Assessing Interactions Among Stations in the Space and Terrestrial Services

GENERAL

Chapter 8 of this Manual contains criteria and procedures applicable to spectrum sharing among stations in the space radiocommunication services and between stations in the space and terrestrial radiocommunication services. This Annex supplements Chapter 8 with supporting data and verification procedures appropriately cross-referenced to the various Sections of Chapter 8.

Limitations on Power and Direction of Maximum Radiation of Stations in the Fixed Service in the Band 8025-8400 MHz

Power and antenna pointing limitations are specified in Section 8.2.34. A description is also provided therein of two computerized procedures for checking proposed new stations or systems for compliance with the specified limits during the FAS and SPS review processes.

The following table will assist in ensuring that the main antenna beam of a fixed or mobile station does not point at the geostationary orbit. This table is appropriate for use by Government agencies in the earlier planning stages of systems in the fixed and mobile services, within the limitations imposed by the following basic assumptions:

- (a) an e.i.r.p. of +55 dBW, and therefore, a required separation angle of 1.5° from the geostationary orbit;
- (b) an angle of elevation of the antenna main beam between -1° and $+4^\circ$; and,
- (c) atmospheric refraction in the range of -2° to 0° .

For an assignment to a station with an anten-

na elevation angle between -1° and $+4^\circ$ with an e.i.r.p. of less than +55 dBW, the azimuthal sectors to be avoided will be smaller, but are contained within the sectors indicated in the table. This table cannot be used where the elevation angle is not between -1° and $+4^\circ$. Calculation of the azimuthal sectors to be avoided for elevation angles not between -1° and $+4^\circ$ should be accomplished using CCIR Report 393.

RANGES OF AZIMUTHS TO BE AVOIDED Northern Hemisphere				
Latitude of Terrestrial Station (N)	From	To	From	To
0	88.50	91.50	268.50	271.50
1	88.60	91.73	268.27	271.40
2	88.70	91.95	268.05	271.30
3	88.80	92.18	267.82	271.20
4	88.90	92.41	267.59	271.10
5	88.99	92.63	267.37	271.01
6	89.09	92.86	267.14	270.91
7	89.19	93.09	266.91	270.81
8	89.29	93.33	266.67	270.71
9	89.38	93.56	266.44	270.62
10	89.48	93.80	266.20	270.52
11	89.58	94.04	265.96	270.42
12	89.68	94.28	265.72	270.32
13	89.78	94.52	265.48	270.22
14	89.88	94.76	265.24	270.12
15	89.97	95.01	264.99	270.03
16	90.07	95.26	264.74	269.93
17	90.17	95.52	264.48	269.83
18	90.27	95.77	264.23	269.73
19	90.38	96.03	263.97	269.62
20	90.48	96.30	263.70	269.52
21	90.58	96.57	263.43	269.42
22	90.68	96.84	263.16	269.32
23	90.79	97.12	262.88	269.21
24	90.89	97.40	262.60	269.11
25	91.00	97.69	262.31	269.00

RANGES OF AZIMUTHS TO BE AVOIDED Northern Hemisphere (continued)				
Latitude of Terrestrial Station (N)	From	To	From	To
26	91.11	97.98	262.02	268.89
27	91.22	98.28	261.72	268.78
28	91.33	98.58	261.42	268.67
29	91.44	98.89	261.11	268.56
30	91.56	99.21	260.79	268.44
31	91.67	99.54	260.46	268.33
32	91.79	99.87	260.13	268.21
33	91.91	100.21	269.79	268.09
34	92.03	100.56	259.44	267.97
35	92.16	100.92	259.08	267.84
36	92.28	101.29	258.71	267.72
37	92.41	101.67	258.33	267.59
38	92.54	102.06	257.94	267.46
39	92.68	102.46	257.54	267.32
40	92.82	102.88	257.12	267.18
41	92.96	103.31	256.69	267.04
42	93.11	103.75	256.25	266.89
43	93.26	104.21	255.79	266.74
44	93.41	104.69	255.31	266.59
45	93.57	105.19	254.81	266.43
46	93.74	105.70	254.30	266.26
47	93.91	106.24	253.76	266.09
48	94.08	106.80	253.20	265.92
49	94.26	107.38	252.62	265.74
50	94.45	107.99	252.01	265.55
51	94.65	108.63	251.37	265.35
52	94.85	109.30	250.70	265.15
53	95.06	110.00	250.00	264.94
54	95.29	110.74	249.26	264.71
55	95.52	111.53	248.47	264.48
56	95.76	112.35	247.65	264.24
57	96.02	113.23	246.77	263.98
58	96.29	114.17	245.83	263.71
59	96.57	115.17	244.83	263.43

RANGES OF AZIMUTHS TO BE AVOIDED Northern Hemisphere (continued)				
Latitude of Terrestrial Station (N)	From	To	From	To
60	96.87	116.23	243.77	263.13
61	97.19	117.38	242.62	262.81
62	97.52	118.61	214.39	262.48
63	97.88	119.95	240.05	262.12
64	98.27	121.40	238.60	261.73
65	98.68	122.99	237.01	261.32
66	99.13	124.73	235.27	260.87
67	99.60	126.66	233.34	260.40
68	100.13	128.82	231.18	259.87
69	100.69	131.25	228.75	259.31
70	101.31	134.02	225.98	258.69
71	102.00	137.23	222.77	258.00
72	102.75	141.03	218.97	257.25
73	103.60	145.68	214.32	256.40
74	104.55	151.67	208.33	255.45
75	105.62	160.34	199.66	254.38

RANGES OF AZIMUTHS TO BE AVOIDED Southern Hemisphere				
Latitude of Terrestrial Station (N)	From	To	From	To
0	88.50	91.50	268.50	271.50
1	88.27	91.40	268.70	271.73
2	88.05	91.30	268.70	271.95
3	87.82	91.20	268.80	272.18
4	87.59	91.10	268.90	272.41
5	87.37	91.01	268.99	272.63
6	87.14	90.91	269.09	272.86
7	86.91	90.81	269.19	273.09
8	86.67	90.71	269.29	273.33
9	86.44	90.62	269.38	273.56
10	86.20	90.52	269.48	273.80

RANGES OF AZIMUTHS TO BE AVOIDED Southern Hemisphere (continued)				
Latitude of Terrestrial Station (N)	From	To	From	To
11	85.96	90.42	269.58	274.04
12	85.72	90.32	269.68	274.28
13	85.48	90.22	269.78	274.52
14	85.24	90.12	269.88	274.76
15	84.99	90.03	269.97	275.01
16	84.74	89.93	270.07	275.26
17	84.48	89.83	270.17	275.52
18	84.23	89.73	270.27	275.77
19	83.97	89.62	270.38	276.03
20	83.70	89.52	270.48	276.30
21	83.43	89.42	270.58	276.57
22	83.16	89.32	270.68	276.84
23	82.88	89.21	270.79	277.12
24	82.60	89.11	270.89	277.40
25	82.31	89.00	271.00	277.69
26	82.02	88.89	271.11	277.98
27	81.72	88.78	271.22	278.28
28	81.42	88.67	271.33	278.58
29	81.11	88.56	271.44	278.89
30	80.79	88.44	271.56	279.21
31	80.46	88.33	271.67	279.54
32	80.13	88.21	271.79	279.87
33	79.79	88.09	271.91	280.21
34	79.44	87.97	272.03	280.56
35	79.08	87.84	272.16	280.92
36	78.71	87.72	272.28	281.29
37	78.33	87.59	272.41	281.67
38	77.94	87.46	272.54	282.06
39	77.54	87.32	272.68	282.46
40	77.12	87.18	272.82	282.88
41	76.69	87.04	272.96	283.31
42	76.25	86.89	273.11	283.75
43	75.79	86.74	273.26	284.21
44	75.31	86.59	273.41	284.69

RANGES OF AZIMUTHS TO BE AVOIDED Southern Hemisphere (continued)				
Latitude of Terrestrial Station (N)	From	To	From	To
45	74.81	86.43	273.57	285.19
46	74.30	86.26	273.74	285.70
47	73.76	86.09	273.91	286.24
48	73.20	85.92	274.08	286.80
49	72.62	85.74	274.26	287.38
50	72.01	85.55	274.45	287.99
51	71.37	85.35	274.65	288.63
52	70.70	85.15	274.85	289.30
53	70.00	84.94	275.06	290.00
54	69.26	84.71	275.29	290.74
55	68.47	84.48	275.52	291.53
56	67.65	84.24	275.76	292.35
57	66.77	83.98	276.02	293.23
58	65.83	83.71	276.29	294.17
59	64.83	83.43	276.57	295.17
60	63.77	83.13	276.87	296.23
61	62.62	82.81	277.19	297.38
62	61.39	82.48	277.52	298.61
63	60.05	82.12	277.88	299.95
64	58.60	81.73	278.27	301.40
65	57.01	81.32	278.68	302.99
66	55.27	80.87	279.13	304.73
67	53.34	80.40	279.60	306.66
68	51.18	79.87	280.13	308.82
69	48.75	79.31	280.69	311.25
70	45.98	78.69	281.31	314.02
71	42.77	78.00	282.00	317.23
72	38.97	77.25	282.75	321.03
73	34.32	76.40	283.60	325.68
74	28.33	75.45	284.55	331.67
75	19.66	74.38	285.62	340.34

**Earth Station Antenna Elevation Angle
and EIRP Toward the Horizon**

For transmitting earth stations in the bands 7900-7975 and 8025-8400 MHz, Section 8.2.35 places an upper limit on the equivalent isotropically radiated power (EIRP) toward the horizon and a minimum antenna elevation angle above the horizontal plane.

Earth stations should be evaluated for compliance with those provisions before or at the time of the systems review under Chapter 10. An algorithm to perform this evaluation is presented below together with an illustrative example.

Algorithm

Frequency Check: Determine whether the system under consideration includes a transmitting earth station operating in either the 7900-7975 or 8025-8400 MHz band. If it does not, terminate the check. Does the transmitting earth station operate in either of the above bands?

YES ☐ NO ☐

Antenna Elevation Angle: Check for compliance with minimum antenna elevation angle requirements. Use the planned minimum operating elevation angle of the antenna as provided in the systems review data. The requirements for the various services are as follows:

- Space Research (Deep Space) > 10°
- Space Research (Near Earth) > 5°
- Other Earth Stations > 3°

If the appropriate limitation is not met, the constraints of Section 8.2.35 are violated. Does the station meet the criteria for the applicable service?

YES ☐ NO ☐

EIRP Limitations: These limitations are a function of the horizon elevation angle. As an upper bound on the EIRP limitation, determine

the maximum EIRP in a 409kHz band (antenna mainbeam gain in dB above isotropic + maximum power density in dBW/Hz + 36 dB [conversion from 1 Hz to 4 kHz]). If this value is below 40 dBW/4 kHz, then the system meets the EIRP criteria, if not, perform the more detailed examination explained below.

Compute the EIRP/4 kHz (P_h) radiated toward the horizon for **each** intended operating azimuth using the following data:

Note: All data elements are required under Chapter 10 by reference to Appendixes 3 and 4 to the ITU Radio Regulations.

- Φ Planned operating azimuth angles;
- θ_2 Elevation angle of the horizon measured from the horizontal plane for the Φ azimuth;
- θ_1 Operating elevation angle of the antenna above the horizontal plane for the Φ azimuth;
- G Antenna pattern information; and
- P Maximum power density in dBW/Hz averaged over the worst 409 kHz band.

Computation:

$$P_h = P + 36 + G^\Phi (\theta_1 - \theta_2) \text{ dBW/4 kHz}$$

Where $G^\Phi (\theta_1 - \theta_2)$ is the gain of the antenna ($\theta_1 - \theta_2$) degrees off axis, determined for each azimuth Φ .

Check P_h (EIRP/4 kHz) for compliance with the following limits:

Horizon	P_h limits
$\theta_2 > 5^\circ$	No restriction
$0^\circ < \theta_2 \leq 5^\circ$	$< 40 + 3 \theta_2 \text{ dBW/4 kHz}$
$\theta_2 \leq 0^\circ$	$< 40 \text{ dBW/4 kHz}$

If P_h exceeds these limits, the constraints of Section 8.2.35 are violated. Does the station meet the above EIRP limits?

YES ☐ NO ☐

A station to be in compliance with Section

8.2.35 must conform to the criteria under the three headings above for all azimuths.

Illustrative Example

Data Submitted:

Station: Earth Station in the Fixed-Satellite Service.

Frequency: 8.23 GHz.

Power Density: $P = -6$ dBW/Hz.

Mainbeam Azimuth: $\Phi = 103^\circ$

Mainbeam Elevation Angle: $\theta_1 = 8^\circ$ for $\Phi = 103^\circ$.

Horizon Elevation Angle: $\theta_2 = 3^\circ$ for $\Phi = 103^\circ$ (extracted from geographical data provided for horizon around earth station).

Mainbeam Antenna Gain: 51 dB.

Antenna Gain: $G^\Phi(\theta_1 - \theta_2) = 14.5$ dB.

This gain is at the natural horizon at an azimuth of 103° and is taken from a point on the graphical antenna pattern 5° from the center of the mainbeam ($\theta_1 - \theta_2 = 5^\circ$).

Frequency Check: The submitted transmitting frequency is in one of the specified bands.

Operating Elevation Angle: The minimum operating elevation angle of 8° does meet the criteria for the fixed-satellite service.

EIRP Limitations: The maximum EIRP is 81 dBW/4 kHz ($51 + 36 - 6$ dBW/4 kHz). As this exceeds the value of 40 dBW/4 kHz, a detailed examination must be made.

Computation of EIRP toward the horizon:

$$\begin{aligned} P_h &= -6 + 36 + 14.5 \text{ dBW/4 kHz} \\ &= 44.5 \text{ dBW/4 kHz} \end{aligned}$$

The criterion for a horizon elevation of 3° is 49 dBW/4 kHz ($40 + 3.3^\circ$). The computed EIRP toward the horizon is less than the criterion and therefore complies with the constraint.

As the data in this example meet the criteria in each of the headings, the station complies with Section 8.2.35.

POWER FLUX DENSITY LIMITS

Section 8.2.36 specifies constraints on the power flux density (PFD) from space stations in certain bands. The constraints are of three forms: a) PFD limits at the Earth's surface in dBW/m²/4 kHz (or in some bands /1 MHz or /1.5 MHz); b) power spectral density at the receiver input of a troposcatter system in dBW/4 kHz; and c) PFD limits in dBW/m²/4 kHz at the geostationary orbit from space stations using non-geostationary orbits.

The latter constraint is applicable only to the space-to-Earth operations in the earth exploration-satellite service in the band 8025-8400 MHz. Compliance with this provision of Section 8.2.36 will be examined on a case-by-case basis and will not be further considered in the Annex.

The constraint on the power spectral density from a space station at the receiver input of a troposcatter system applies in the bands 1670-1700, 1700-1710, and 2200-2300 MHz. In view of the very small number of troposcatter systems within the US&P in these bands, examination of proposed systems for compliance with this provision will be considered on a case-by-case basis.

Limitations on the PFD at the Earth's surface from a space station are imposed in most of the down-link bands between 1670 MHz and 22 GHz which are shared with the terrestrial services. Evaluation of space stations for compliance with this provision should be accomplished before or at the time of the systems review under Chapter 10. An algorithm to perform this evaluation is presented below together with an illustrative example.

Algorithm

This algorithm checks compliance with the PFD limits at the Earth's surface from a space station in the geostationary orbit.

Frequency Band/Service Check: Determine whether the proposed system is for one of the combinations of frequency band and radio

service given in Table 1. If it is not, terminate the check. Determine whether the satellite is in the geostationary orbit. If it is not, a case-by-case review is necessary. Is the space station in a geostationary orbit and in a frequency band and service combination given in Table 1?

YES ☐ NO ☐

Power Flux Density Limits: The PFD of the station at the Earth's surface must be computed and compared with established criteria. When earth coverage antennas are used in the satellite, the antenna gain across the visible portion of the Earth's surface is assumed to be constant. When spot beam antennas are used, a worst case is assumed (full gain) unless a complete description of the pattern, side lobes, and exact pointing direction is provided. In that case a detailed examination is necessary.

The most stringent PFD limitation on satellites with earth coverage antennas is imposed for low angles of arrival at the Earth's surface. Thus the computed PFD is compared with the limits imposed at low angles of arrival (see Table 1).

It is recognized that the limitations are referenced to different bandwidths, i.e., 4 kHz, 1 MHz, and 1.5 MHz. Thus it is necessary to select the appropriate bandwidth from Table 1 for the particular band and service under consideration.

In computing the PFD, it is assumed that:

- (a) atmospheric losses are negligible;
- (b) the geostationary orbit is 37,500 km; and,
- (c) the Earth's radius is constant, i.e., the Earth is smooth.

To compute the power flux density P_E at the Earth's surface, the following data are used:

- P_d Maximum power spectral density in dBW/Hz averaged over the reference bandwidth (4 kHz, 1 MHz, or 1.5 MHz).
- B_r Reference bandwidth in Hz.
- G Mainbeam antenna gain in dB.

The computation to determine the power flux density is:

$$P_E = P_d + 10 \log B_r + G - 163 \text{ dBW/m}^2/\text{B}_r$$

Once this value is determined, it is checked against the appropriate criteria given in Table 1.

Is the computed PFD less than (more negative) than the applicable value given in Table 1?

YES ☐ NO ☐

A station to be in compliance with Section 8.2.36 must conform to the criteria specified in Table 1.

Illustrative Example

Data Submitted:

Frequency Band: 7300-7750 MHz.

Service: Fixed-Satellite.

Orbit: Geostationary.

Power Density: -46 dBW/Hz.

Antenna Gain: 17 dB.

TABLE 1

COORDINATED EARTH STATIONS

Power Flux Density Limits at the Earth's Surface from Space Stations in Bands Shared with the Fixed and Mobile Services		
Frequency Band (MHz)	Space Radiocommunication Service	Limit
1670-1690	Meteorological-Satellite	-154dBW/m ² / 4 kHz
1690-1700	Meteorological & Earth Exploration-Satellite (for countries mentioned in ITU RR 741)	
1700-1710	Space Research	
2200-2300	Space Research	
7300-7750	Fixed-Satellite	
7450-7550	Meteorological-Satellite	-152dBW/m ² / 4 kHz
8025-8400	Fixed-Satellite	-150dBW/m ² / 4 kHz
8025-8400	Earth Exploration-Satellite	
8400-8500	Space Research	
21200-22000	Earth Exploration-Satellite	
1690-1700	Meteorological & Earth Exploration-Satellite	-133dBW/m ² / 4 kHz

(See Sections 8.3.12, 8.3.13, 8.3.15)

On the succeeding pages, coordination contours and associated data for previously coordinated earth stations are provided as a matter of record and to assist agencies in determining requirements for coordination of proposed new terrestrial stations. This information supplements that given in Section 8.3.15.



Frequency Band/Service Check: The space station described above is in the geostationary orbit and operates in a frequency band and radiocommunication service given in Table 1.

Power Flux Density Limits: The reference bandwidth for the band under consideration is 4 kHz. Using this value and the above data, the computed power flux density is $-156 \text{ dBW/m}^2/4 \text{ kHz}$ ($-46 + 36 + 17 - 163 \text{ dBW/m}^2/4 \text{ kHz}$). This value is less than (more negative) the limit of $-152 \text{ dBW/m}^2/4 \text{ kHz}$ specified in Table 1, and, therefore, the station complies with the provisions in Section 8.2.36.